

**Statement of  
Michael H. Freilich  
Director, Earth Science Division  
Science Mission Directorate  
National Aeronautics and Space Administration**

**before the**

**Committee on Commerce, Science, and Transportation  
United States Senate**

Mr. Chairman and Members of the Committee, thank you for the opportunity to appear today to discuss how NASA partners with the National Oceanic and Atmospheric Administration (NOAA). As the Director of the Earth Science Division, one of four science divisions that make up the NASA Science Mission Directorate, I welcome this opportunity to discuss the important area of Earth Science and our collaborations with NOAA. This discussion is especially timely in light of the recently released National Research Council's (NRC's) Earth Science Decadal Survey, which outlines specific scientific priorities for both NASA and NOAA.

Much of the science community's present state of knowledge about global change – including many of the measurements and a significant fraction of the analyses which serve as the foundation for the recent report of the Intergovernmental Panel on Climate Change (IPCC) – is derived from NASA's Earth Science program. Using data from Earth observing satellites, NASA-supported researchers are monitoring ice cover and ice sheet motions in the Arctic and the Antarctic; quantifying the short-term and long-term changes to the Earth's protective shield of stratospheric ozone, including the positive impacts of the Montreal protocols; discovering robust relationships between increasing upper ocean temperature and decreasing primary production from the phytoplankton that form the base of the oceans' food chain; and, using a fleet of satellites flying in formation (the "A-Train"), making unique, global, near-simultaneous measurements of aerosols, clouds, radiative fluxes, and temperature and relative humidity profiles.

NASA researchers codify our improving understanding of Earth processes in sophisticated weather and climate models which can then be used to predict natural and human-caused environmental changes. Researchers often analyze the gridded "nowcast" output from these numerical prediction models as proxies for actual data, since the model predictions incorporate all available observations. Improved operational models thus aid the research endeavor as well as yield improved forecasts.

There is thus a strong synergy between our Nation's research satellites and our operational spaceborne systems. Near-real-time measurements from NASA research missions such as the Tropical Rainfall Measuring Mission (TRMM), the Quick Scatterometer (QuikSCAT), the Atmospheric Infrared Sounder (AIRS) instrument on the Aqua mission, and others are used routinely by NOAA and other U.S. and international agencies to improve weather and extreme event forecasts. Similarly, high quality measurements obtained by Department of Defense (DoD) and NOAA operational weather satellites provide essential context for the scientific analyses of the NASA research mission data. As the Nation's civil space agency, NASA demonstrates and refines new measurement technologies and then works closely with NOAA in an effort to transition these research capabilities to long-term operations.

NASA joins with other Federal agencies to support an integrated Federal program of climate research. Consistent with the NASA Space Act of 1958, as amended, and the NASA Authorization Act of 2005 (P.L. 109-155), NASA's role within the broader federal program is guided by the U.S. National Space Policy, authorized by the President on August 31, 2006. NASA's contribution to the U.S. Climate Change Science Program (CCSP) is unchanged from the FY 2007 to FY 2008 budget request, and remains the largest single contribution to the Program. NASA, NOAA, and the U.S. Geological Survey (USGS) jointly requested that the National Research Council conduct a Decadal Survey for Earth Science. The recently completed survey outlines specific scientific priorities for both NASA and NOAA.

NASA works closely with NOAA, in particular, in an effort to transition mature and proven measurement capabilities to long-term operations. In addition to the NASA-NOAA Joint Working Group (established by the NASA Authorization Act of 2005) which has addressed a wide range of issues related to transition of measurements and data products, the two agencies also meet regularly in more focused fora such as the Interagency Altimeter Group (NASA, NOAA, Navy). Since early summer of 2006, NASA and NOAA have worked intensely with each other and with the Office of Science and Technology Policy (OSTP) to document the impacts of, and develop mitigation strategies for, changes to the National Polar-orbiting Operational Environmental Satellite System (NPOESS) made in relation to Nunn-McCurdy recertification of the program.

Below, as requested, we address status and collaborative activities related to the three missions identified as of particular interest to the Committee: NPOESS, Geostationary Operational Environmental Satellites (GOES) -R, and QuikSCAT.

#### **NPOESS**

NPOESS was established in 1994 by Presidential Decision Directive to combine the previously separate operational, Earth-observing satellite systems operated by DoD (the Defense Meteorological Satellite Program, (DMSP)) and NOAA (the Polar-orbiting Operational Environmental Satellite program, (POES)). The primary objective of both DMSP and POES was to collect measurements in support of weather and environmental forecasting. However, as noted above, in many cases high-quality, well-validated, operational data products acquired by these systems are used extensively by the Earth science research community as well.

The overall NPOESS program is composed of two spaceborne elements: the NPOESS Preparatory Project (NPP), presently scheduled for launch in September, 2009; and, the NPOESS Operational Constellation (NPOESS), composed of a series of four spacecraft, flying two at a time in coordinated morning and afternoon orbits (the launch of the first of these spacecraft currently is scheduled for 2013).

NPP has two basic aims: 1) to continue the time series of selected climate science measurements initiated by the NASA Earth Observing System spacecraft – in particular, the suite of data products generated by the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument on the Terra and Aqua missions and planned to be produced by the Visible/Infrared Imager/Radiometer Suite (VIIRS) on NPP and NPOESS; and 2) to serve as risk reduction for the future operational NPOESS sensors. NASA, NOAA, and DoD all participate essentially equally in the NPP mission. NASA is responsible for development of the spacecraft bus, launch vehicle, integration and test of the instruments on the spacecraft, and provision of the Advanced Technology Microwave Sounder (ATMS) instrument that will provide all-weather, global temperature and humidity profiles. Through the NPOESS Integrated Program Office (IPO), NOAA and DoD are responsible for development and provision of the VIIRS, Cross-Track Infrared Sounder (CrIS), and Ozone Mapping and Profiling Suite (OMPS) instruments; on-orbit mission operations; and the ground system for the generation of operational products.

The NASA-supplied ATMS instrument was delivered in October 2005 and is presently integrated onto the NPP spacecraft. In response to the removal of the OMPS-Limb profiling capability from both NPP and NPOESS via the Nunn-McCurdy process, NASA and NOAA provided resources from core programs to allow the OMPS-Limb instrument to be re-manifested on NPP in April, 2007, thus restoring both the nadir total ozone measurements and the limb profiling capabilities for NPP. This first-ever combination of total and vertically resolved ozone measurements will provide scientists unique insight into the dynamical and chemical processes that regulate atmospheric composition.

Both the IPO-developed VIIRS and CrIS instruments are presenting significant development challenges. The first CrIS flight unit suffered a structural failure during testing in October 2006, requiring structural design changes and delaying delivery of a flight unit for integration onto the NPP satellite until March 2008. Initial testing is indicating that the VIIRS measurements may be less accurate than those of the present NASA MODIS instruments. The NASA NPP Science Team is working closely with NOAA and IPO personnel to evaluate the impacts of these instrument performance shortfalls on NASA's Earth system science objectives. Although these analyses are in an early stage, it is likely that the present VIIRS flight model for NPP will lack the accuracy and precision to support NASA research related to ocean color and aerosols unless significant resources are applied to implement sensor changes.

The future operational NPOESS system was significantly restructured in June 2006 as a result of the Nunn-McCurdy recertification. The original series of two, 3-satellite constellations was downsized to two, 2-satellite constellations with measurements from the mid-morning orbit to be supplied by the European EUMETSAT MetOp missions. Furthermore, the Nunn-McCurdy process focused NPOESS on its core weather forecasting objectives, removing several important climate sensors and degrading the performance of certain other instruments. The recertified NPOESS does not include total solar irradiance and Earth radiation budget instruments, an altimeter to make accurate global measurements of sea level, and the OMPS-Limb capability to measure vertical profiles of tropospheric and stratospheric ozone. In addition, the Conically Scanning Microwave Imager/Sounder (CMIS) was replaced by a Microwave Imaging Sensor (MIS) whose detailed capabilities have not yet been defined. From the standpoint of addressing NASA science objectives, this change from CMIS to MIS may substantially reduce our ability to acquire all-weather sea-surface temperature measurements as well as information on surface wind direction and speed over the ice-free oceans.

The Decadal Survey, the U.S. Climate Change Science Program, and NASA's own planning in Earth science all assume the presence of an operational system of environmental monitoring satellites that can make climate-quality measurements. Indeed, that is a major reason why NASA, along with NOAA and the Air Force, is a member of the NPOESS governing body. As the Decadal Survey committee was finalizing its notional mission set and sequence, the full impact of the removal of the climate sensors from the NPOESS program was just coming to light. Since last summer, NASA has been working closely with NOAA, OSTP, and the scientific research community to understand and rank the impacts of these programmatic perturbations and to develop realistic mitigation scenarios for the most important measurements. In addition to our agency-based technical evaluations and preliminary mitigation strategy designs, NASA and NOAA commissioned, supported, and participated in a National Research Council workshop held June 19-21, 2007, after several weeks of community planning (including participation by members of the original Decadal Survey committee). The workshop was chartered to examine the scientific and research-focused impacts of the programmatic changes to NPOESS and to consider various potential recovery scenarios. NASA and NOAA anticipate receiving the workshop report later this summer.

## **GOES-R**

NASA has historically managed the development and launch of the Geostationary Operational Environmental Satellite (GOES) system under a reimbursable work agreement with and in support of NOAA. Two legacy GOES spacecraft are presently built and in ground storage. Work has begun on design and development for the next-generation GOES series known as “GOES-R.” These spacecraft will fly an advanced imager capable of simultaneous focused high resolution measurement and full-field low resolution acquisition. The GOES-R instrument complement will also include a first-ever lightning sensor capable of operating from geostationary orbit, as well as a complement of space weather instrumentation. NASA will manage the spaceborne hardware portion of GOES-R for NOAA as a reimbursable project through a program office at NASA’s Goddard Space Flight Center in Greenbelt, Maryland.

## **QuikSCAT**

Launched on June 19, 1999, QuikSCAT carries as its only science instrument an active radar scatterometer instrument that provides ocean surface vector wind data under nearly all-weather conditions. QuikSCAT’s primary mission is scientific research, but from the start NASA and NOAA recognized the value of the ocean surface vector wind data for operational weather and marine hazard forecasting. Prior to launch, NASA and NOAA collaborated to assure that QuikSCAT data could be downlinked to Earth and processed sufficiently rapidly to be useful to NOAA for weather forecasting. The NASA-NOAA collaboration included both use of distributed ground telemetry stations, and development by NASA’s Jet Propulsion Laboratory (JPL) in Pasadena, California of specific computer algorithms and data formats to allow rapid processing by NOAA and efficient use of the QuikSCAT wind measurements in NOAA weather forecasting models at the National Weather Service (NWS) National Centers for Environmental Prediction and NWS Weather Forecast Offices having coastal responsibilities.

QuikSCAT has been on orbit for eight years, five years beyond its original three-year baseline mission. Although some redundant subsystems have failed or have suffered degradation (in particular the transmitter which allows the satellite’s measurements to be sent to the ground for processing), backup systems are working well, and the data remain of high quality. The satellite is clearly aging, but shows no indication of imminent failure.

NASA has neither a scientific mandate nor any near-term plan to replace QuikSCAT’s active radar scatterometry measurements. The Decadal Survey identifies a sea surface wind vector scatterometry mission, the Extended Ocean Vector Winds Mission (XOVWM), as a mid-decadal priority for NOAA. NASA continues to work closely with NOAA to support an efficient transition of ocean surface vector wind measurements from research to operations. NOAA is evaluating a number of options for addressing its ocean vector wind requirements and has taken a number of steps including funding a JPL study of QuikSCAT replacement options. The results of this study are due in January 2008 and will help NOAA determine the best way to provide accurate, extensive, all-weather, surface wind speed and direction measurements over the global oceans.

## **Conclusion**

In summary, NASA and NOAA have an ongoing and growing collaborative relationship. The two agencies have complementary programmatic expertise and objectives. Both NASA research to advance Earth system science and NOAA’s prediction objectives require an operational satellite system that can reliably acquire accurate measurements. Both NOAA’s prediction tasks and NASA’s science investigations require the development and on-orbit demonstration of new measurement techniques to improve the scope and quality of measurements. Transitioning from research to operations is challenging,

but the ongoing frequent communication between NOAA and NASA at various technical and management levels, and in a variety of fora, will result in effective solutions for the nation.

I welcome your questions on NASA's Earth science program and its relationship to NOAA.